Physical Layer Protocols & Services
- The purpose of the Physical layer is to create the electrical, optical, or microwave signal that represents the bits in each frame.
- The three fundamental functions are:
  - Data encoding: method of converting a stream of data bits into predefined ‘codes’
  - Signaling: how bits are represented on the physical media
  - The physical components: connectors and cables

Data Carrying Capacity of a Network
- Digital bandwidth is measured in bits per second (bps), kbps, Mbps, Gbps, Tbps

Signaling Methods
- The method of representing the bits is called the signaling method
- The Physical layer standards must define what type of signal represents a “1” and a “0”.
- Non Return to Zero (NZR) is the simplest signaling method used
  - Low voltage represents logic 0, high logic 1. Inefficient. Only suitable for slow links. Problems with long runs of individual bit – loss of synchronization.
The Receiver samples the media in the middle of the bit-time.

- On LANs, clocks at the Sender and Receiver keep in synch by noting the transitions between high and low voltage.
- If a number of consecutive 1’s or 0’s is transmitted, the clocks may drift out of synch and the Receiver may read a bit.

Non Return to Zero (NRZ) Signaling

Manchester Encoding

- The signaling method employed by 10BaseT Ethernet (10Mbps)
- A transition from a low voltage to a high voltage represents a bit value of 1.
- A transition from a high voltage to a low voltage represents a bit value of 0.
- Since every bit involves a transition, the clocks can stay in synch.

The next slide shows the mapping for the code group 4B/5B. Other encodings are generally more complex.

- A code group is a consecutive sequence of code bits (symbol) that are interpreted and mapped as data bits patterns.
- Although using code groups introduces overhead in the form of extra bits to transmit, they improve the robustness of a communications link.
- Advantages using code groups include:
  - Reducing bit level error
  - Limiting the effective energy transmitted into the media
  - Helping to distinguish data bits from control bits
- The next slide shows the mapping for the code group 4B/5B. Other encodings are generally more complex.
4B data code  5B symbol  Control code  5B symbol
0000  11110  idle  11111
0001  01001  start of stream  11000
0010  10100  start of stream  10001
0011  10101  end of stream  01101
0100  01010  end of stream  00111
0101  01011  transmit error  00111
0110  01110  invalid  00000
0111  01111  invalid  00001
1000  10010  invalid  00010
1001  10011  invalid  00011
1010  10110  invalid  00100
1011  10111  invalid  00101
1100  11010  invalid  00110
1101  11011  invalid  01000
1110  11100  invalid  10000
1111  11101  invalid  11001

Copper Media – UTP, STP, Coaxial
- Radio waves and electromagnetic devices are potential sources of noise.
- Cable types are designed to minimize signal degradation due to electronic noise.

UTP Standards
- TIA/EIA-568A stipulates the commercial cabling standards for LAN installations
- IEEE rates UTP cabling, Category 5 (Cat5), Enhanced Category 5 (Cat5e), Category 6 (Cat6).
- Crosstalk is the interference caused by the magnetic field around the adjacent pairs of wires in the cable.
- Twisted pairs of conductors helps prevent crosstalk
- Standard specify the number of twists per meter
- Uses RJ45 jacks and plugs connectors

Unshielded Twisted-Pair (UTP)
- This is the most widely used media for LANs
- Relatively easy to install

UTP Cable Types
- Ethernet Straight-through
  Connects devices to switches and hubs
- Ethernet Crossover
  Connects PC to PC, switch to switch, PC to router
- Rollover
  Cisco proprietary – For device management
UTP Connectors
- Badly fitted connectors is a serious source of network errors

Shielded Twisted-Pair (STP) Cable
- Used in Token Ring network installations.
- The new 10 GB standard for Ethernet has a provision for the use of STP cabling.
- More expensive than UTP, more difficult to install

Coaxial Cable
- Coax cables are used to attach antennas to wireless devices.
- Originally used by cable TV networks, now use fibre with coax bringing signal from street into house
- Combined use of fiber and coax is referred to as hybrid fiber coax (HFC).
- Replaced by UTP and fibre in Ethernet installations. Thick Ethernet, thin Ethernet
- BNC connectors

Fiber-optic Cabling
- Uses glass or plastic fibers to guide light impulses from source to destination.
- Capable of very large raw data bandwidth rates.
- Immune to electromagnetic interference and grounding issues.
- Low signal loss, operate at much greater lengths.
- More expensive than copper media
- Different skills and equipment required to terminate and splice the cable infrastructure
- Requires more careful handling than copper media

Safety issues when working with copper cabling
- Electrical Hazards – earthing.
- Fire Hazards – cable insulation flammable, produce toxic fumes
Two Types of Fiber Cable

- Fiber is primarily used for
  - Backbone cabling for high-traffic point-to-point connections between data distribution facilities
  - Interconnection of buildings in multi-building campuses. (No earthing problems)
- Two types of fiber
  - Multimode 50/125, 62.5/125 cheaper, uses LED light source
  - Singlemode 8/125, 10/125 uses lasers, operate over longer distances

Wireless Media

- Provides mobility for users
- Susceptible to interference
- Security issues

Wireless Standards

- IEEE 802.11 - Wi-Fi, is a Wireless LAN (WLAN) technology that uses a contention or non-deterministic system with a Carrier Sense Multiple Access/Collision Avoidance (CSMA/CA) media access process.
  - IEEE 802.15 - Bluetooth, uses a device pairing process to communicate over distances from 1 to 100 meters.
  - IEEE 802.16 - WiMAX (Worldwide Interoperability for Microwave Access), uses a point-to-multipoint topology to provide wireless broadband access.
  - Global System for Mobile Communications (GSM) - provide data transfer over mobile cellular telephony networks.
  - Satellite communications

Wireless LANs (WLAN, Wi-fi)

- A wireless LAN requires the following network devices:
  - Wireless Access Point (AP) - Concentrates the wireless signals from users and connects, usually through a copper cable, to the existing copper-based network infrastructure such as Ethernet.
  - Wireless NIC adapters - Provides wireless communication capability to each network host.

WLAN Standards

- IEEE 802.11a - 5 GHz frequency band - up to 54 Mbps.
- IEEE 802.11b - Operates in the 2.4 GHz frequency band and offers speeds of up to 11 Mbps. This is the most commonly used standard
- IEEE 802.11g - Operates in the 2.4 GHz frequency band and offers speeds of up to 54 Mbps.
- IEEE 802.11n standard is currently in draft form. 2.4 Ghz or 5 GHz, data rates 100 Mbps to 210 Mbps with a distance range of up to 70 meters